

AIRCRAFT TAKEOFF
PERFORMANCE MONITORING
IN FAR-NORTHERN REGIONS:
AN APPLICATION OF THE
GLOBAL POSITIONING SYSTEM

A Thesis Submitted to the College of
Graduate Studies and Research
in Partial Fulfilment of the Requirements
for the Degree of Doctor of Philosophy
in the Department of Mechanical Engineering
University of Saskatchewan
Saskatoon

By

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April 2003

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ABSTRACT

A design approach for an aircraft takeoff performance monitoring system (TOPMS) is described. In this approach, it is proposed that the Global Positioning System (GPS) in conjunction with a discrete Kalman Filter be used to determine aircraft acceleration, ground speed, and position relative to the end of the runway. A practical evaluation of the feasibility of this proposal showed clear superiority of a GPS-derived acceleration over a more traditional method employing accelerometers. This study found that, when compared to observations from carefully mounted accelerometers, the GPS-derived observation agreed to within 0.10 metres per second squared ninety percent of the time. Advantages of the GPS-derived observation included a modest noise level, insusceptibility to gravity and temperature-influenced variations, and far simplified mounting criteria.

A theoretical dynamic model of an aircraft in contact with the ground was developed in consideration of factors pertaining to runways at far-northern Canadian airports. In the model, factors such as runway slope, wind velocity, wheel friction coefficient, and aircraft control settings were considered constant. While variability in any parameter considered constant by the model could influence the performance of a TOPMS, such variability was deemed beyond the scope of this preliminary investigation of a TOPMS designed specifically for the far-northern environment. A device containing a GPS receiver and data acquisition system was designed and certified, then installed in an aircraft operated by an airline servicing far-northern Canadian airports. The data collected in this manner were used to validate the theoretical model. It was concluded that a projection of displacement can be determined to within an uncertainty of fifteen metres in sufficient time to alert the pilot of an unsafe situation.

ACKNOWLEDGEMENTS

I will begin by acknowledging the corporate sponsorship of Transwest Air. Their willingness to provide space aboard a passenger aircraft for a prototype device enabled the research conducted during this project to be much more relevant than would have been the case with an economical alternative. Partners such as Transwest are rare and invaluable.

My supervisors, Trevor Crowe and Peter Nikiforuk, are two of the most genuinely professional and insightful people I know. Their willingness to allow generous latitude and flexibility in my research was inspiring. While I am sure they would both underestimate their impact on the last few years of my life, I can truly say that I have learned immeasurably from their example and guidance. This went far beyond the technical guidance one might expect of professors of engineering. They have been role models of integrity and professionalism.

Dan Aspel and Glenn Wright are friends who have served as my personal navigation system over the past few years. As with any occupation, or preoccupation, that consumes so much of one's time, friends are often consulted for reassurance regarding the usefulness of the undertaking. I sincerely appreciated the patience of those who acted as my sounding board, as well as the advice that was constantly available.

I would like to thank my family for their support and understanding. While I credit my parents with teaching me to question everything that is generally considered to be factual, an approach which has served me very well in technical matters, they know too well that this particular trait often has a downside. I would like to express my sincere appreciation to my entire family for their patience.

Finally, I would like to acknowledge the support of Claire over the last several years. She has had to endure the conflicting obligations of my teaching, research, and involvement with the Graduate Students' Association which I am sure, at times, must have seemed outrageous when compared to the responsibilities of preparing for our wedding and, more recently, the arrival of our first child. I hope that I have the opportunity someday to make similar sacrifices for her.

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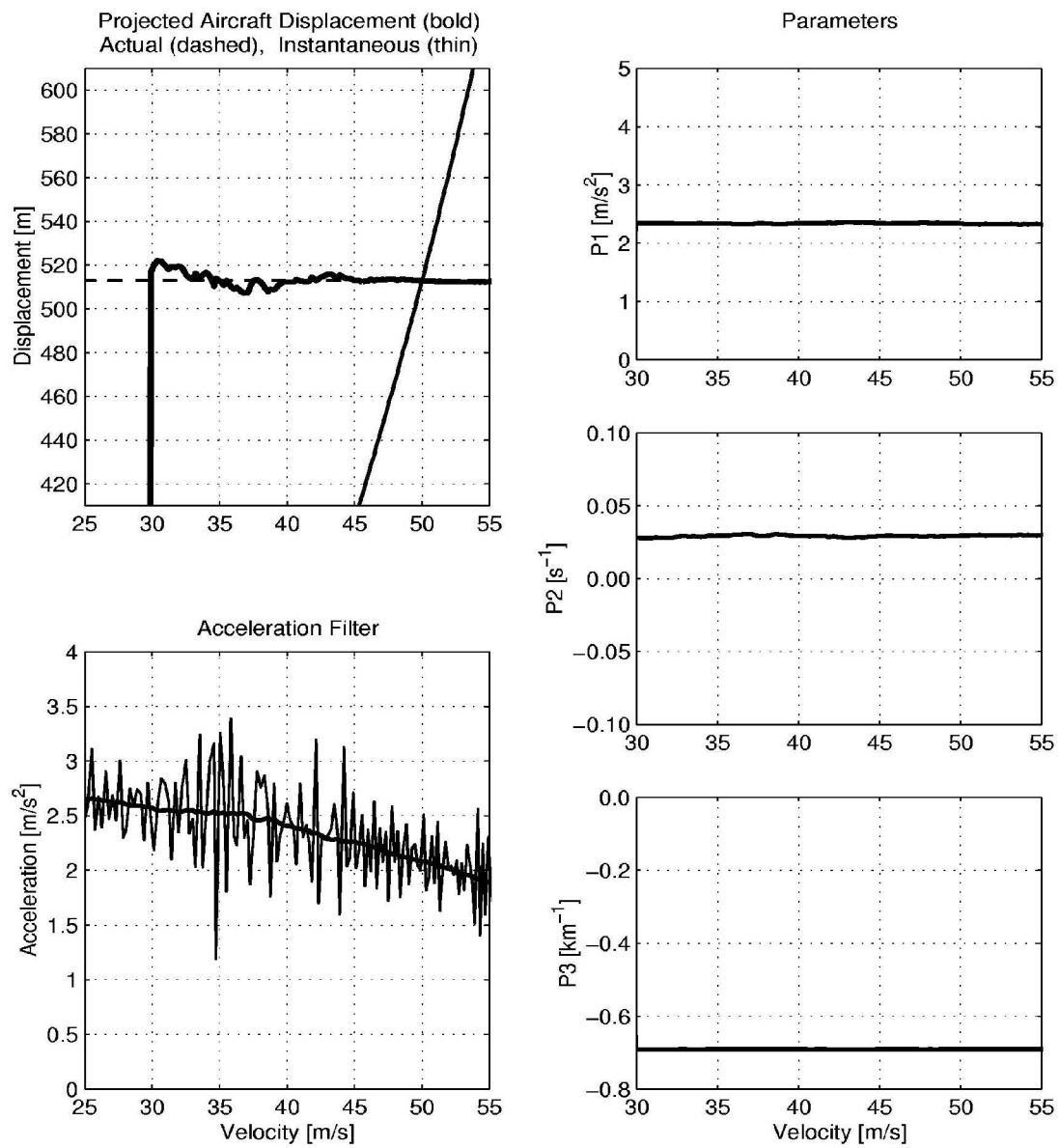
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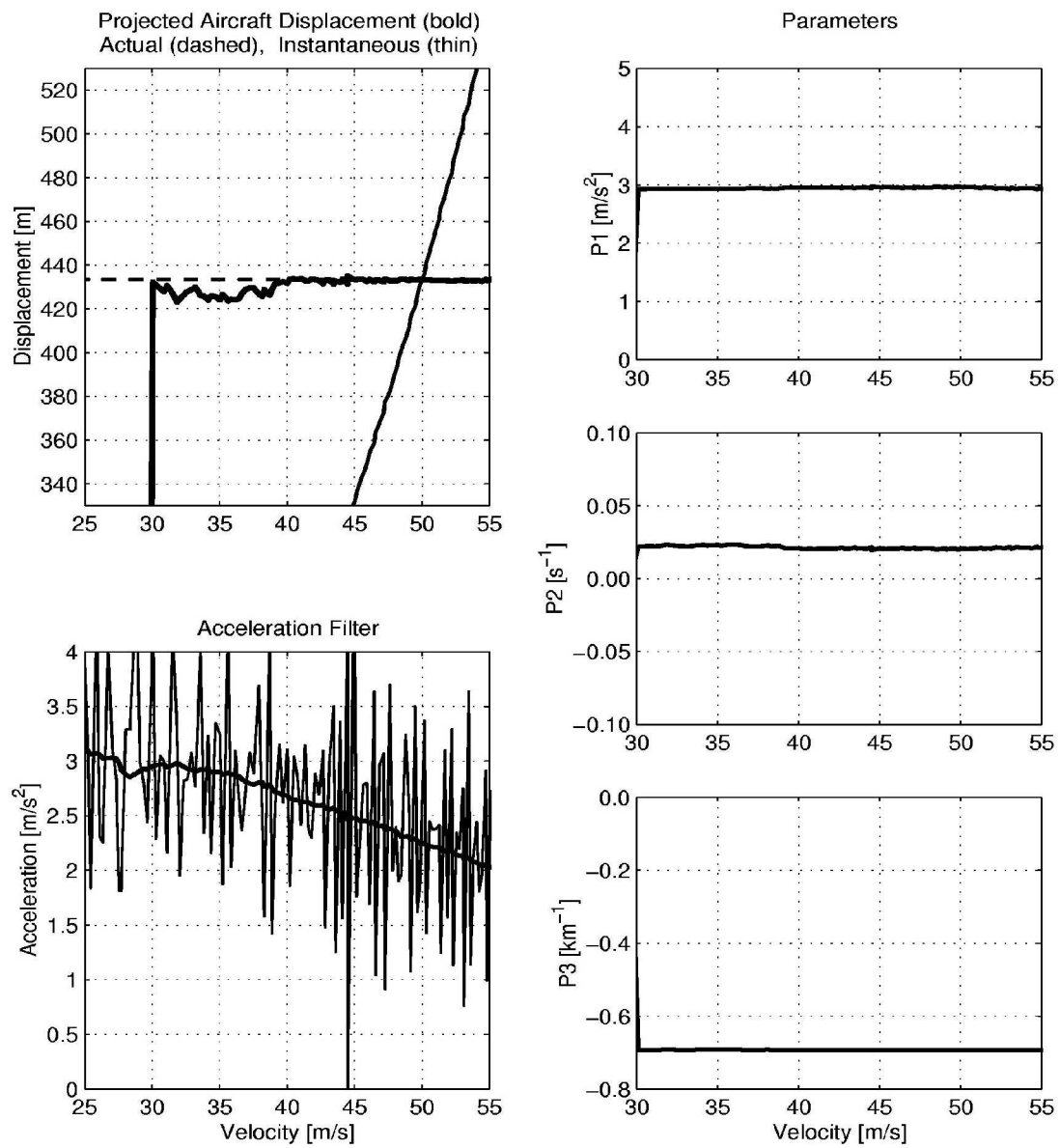
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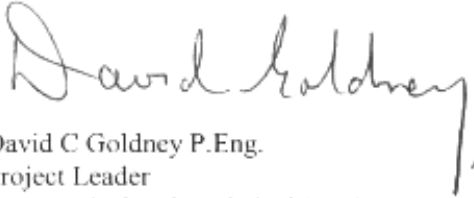
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